"COMPARATIVE ANALYSIS OF FUNCTIONAL OUTCOME OF MULTIPLE METATARSAL FRACTURES TREATED WITH PLATE OSTEOSYNTHESIS AND KIRSCHNER WIRE FIXATION"

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This is to certify that the work **"COMPARATIVE ANALYSIS OF FUNCTIONAL OUTCOME OF MULTIPLE METATARSAL FRACTURES TREATED WITH PLATE OSTEOSYNTHESIS AND KIRSCHNER WIRE FIXATION"**which is being submitted for M.S. Orthopaedics, is a bonafide work of **Dr.C. CHANDRU**, Post Graduate Student at Department of Orthopaedics, Madurai Medical College, Madurai.

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This is to certify that this dissertation **"COMPARATIVE ANALYSIS OF FUNCTIONAL OUTCOME OF MULTIPLE METATARSAL FRACTURES TREATED WITH PLATE OSTEOSYNTHESIS AND KIRSCHNER WIRE FIXATION"** is the bonafide work done by**Dr. C. CHANDRU** under my direct guidance and supervision in the Department of Orthopaedic Surgery, Madurai MedicalCollege, Madurai-20.

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DECLARATION

I, **Dr.C.CHANDRU**, solemnly declare that the dissertation titled**"COMPARATIVE ANALYSIS OF FUNCTIONAL OUTCOME OF MULTIPLE METATARSAL FRACTURES TREATED WITH PLATE OSTEOSYNTHESIS AND KIRSCHNER WIRE FIXATION"**has been prepared by me. This is submitted to **"The Tamil Nadu Dr.M.G.R.MedicalUniversity, Chennai,** in partial fulfilment of the regulations for the award of M S degree branch II Orthopaedics.

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INTRODUCTION:

The human foot is a highly developed, biomechanically complex structure that serves to bear the weight of the body as well as forces many times the weight of the human body during propulsion.

About 26 bones in the human foot provide structural support. They can be grouped into 3 parts, as follows :

- The tarsal bones
- The metatarsal bones
- The phalanges

Apart from these main bones, the sesamoid bones help to improve function and are often found as variants of the accessory bones.

The foot itself can be divided into 3 parts: the hindfoot, the midfoot, and the forefoot. The hindfoot is composed of 2 of the 7 tarsal bones, the talus, and the calcaneus; the midfoot contains the rest of the tarsal bones; and the forefoot contains the metatarsals and the phalanges.

The images below depict the bones of the foot. (Fig 1 and fig 2)

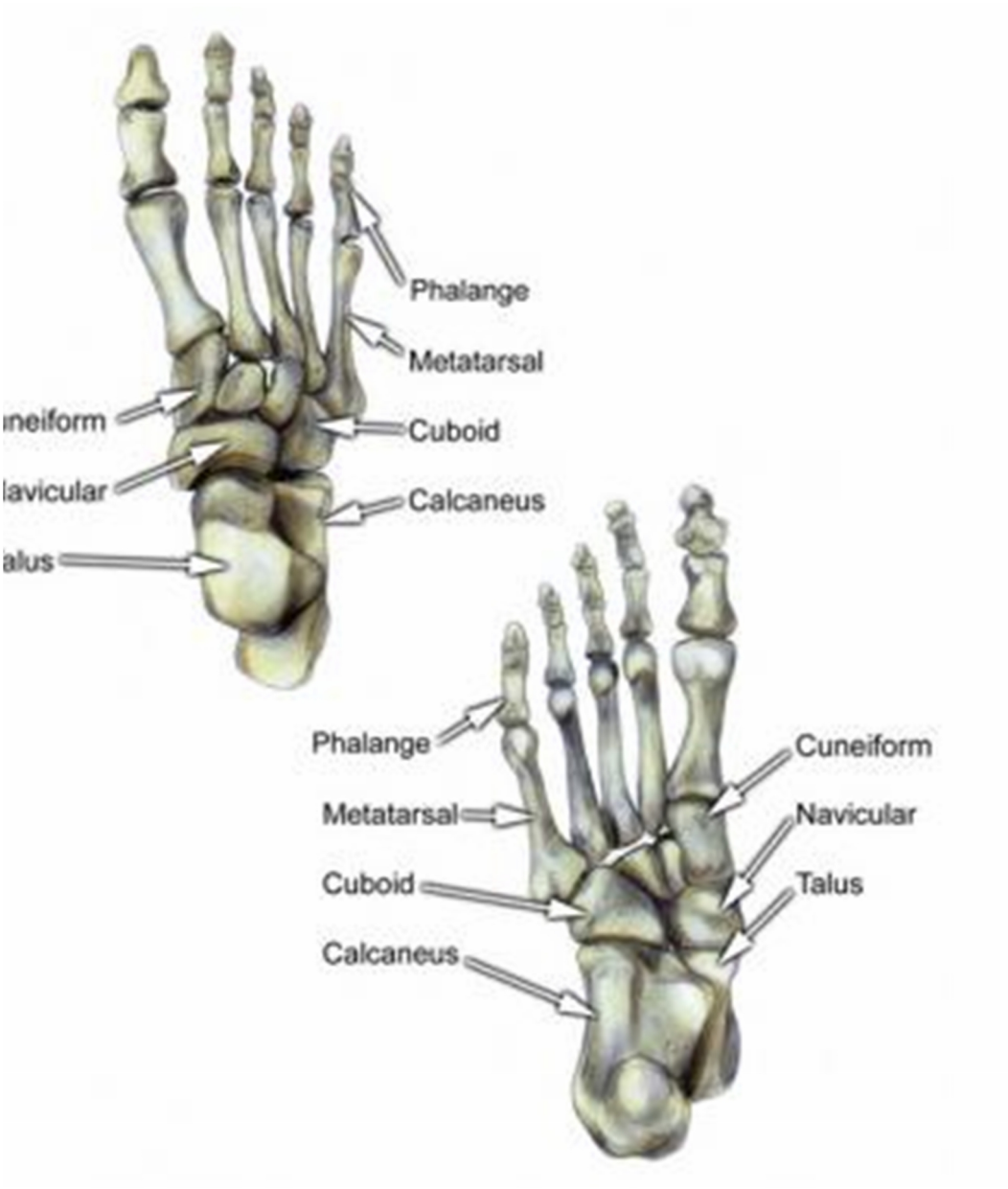


Fig 1:Bones of the foot, dorsal and ventral views.

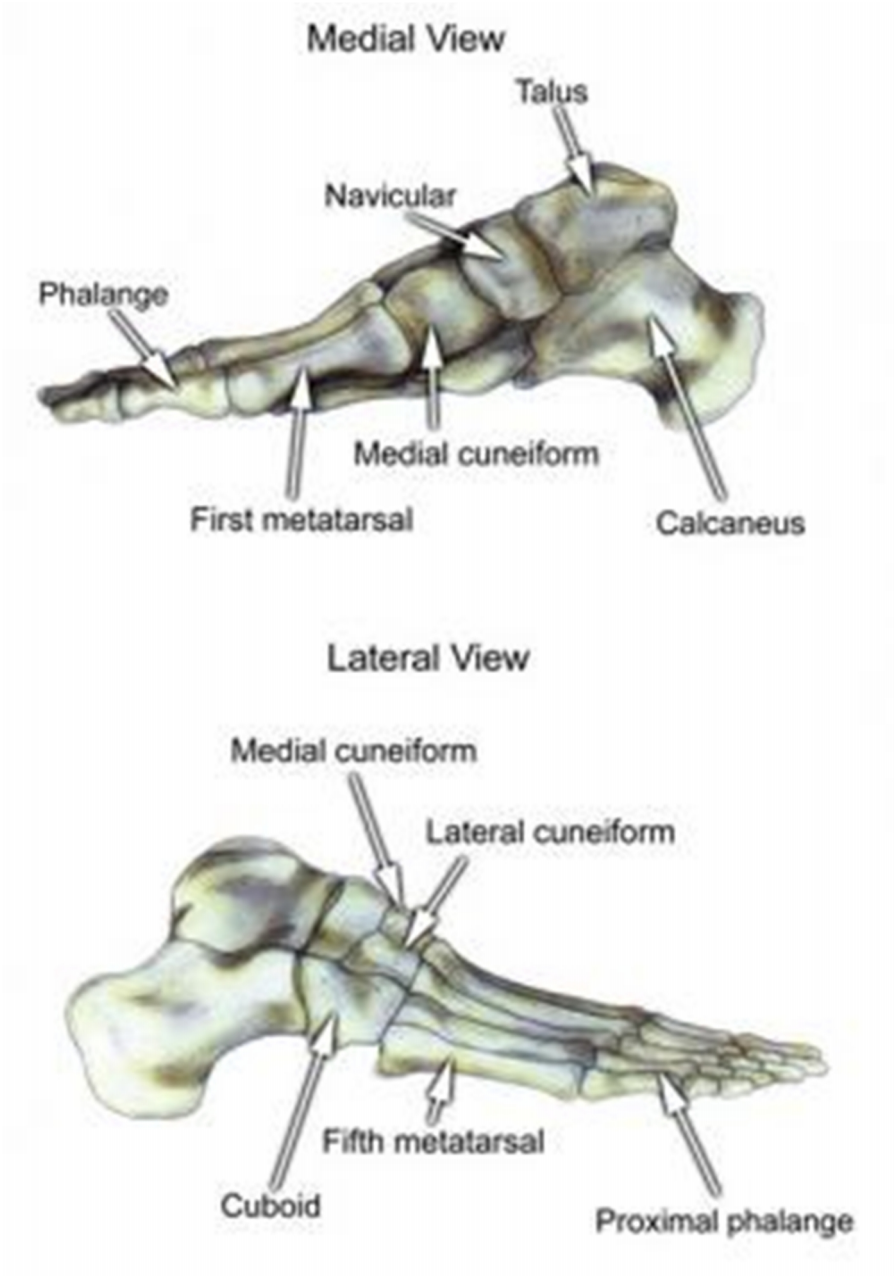


fig 2:Bones of the foot, medial and lateral views.

The modern understanding of the evolutionary anatomy ofthe human foot comprises features such as:

(1) a long Achilles tendon to reduce stress and improve energy efficiency;

(2) apassively stabilized longitudinal plantar arch to improve shock absorption and plantar flexion;

(3) an enlarged calcaneal tuberosity for stress reduction,

(4) a close-packed positioning of the calcaneo-cuboidal joint to improve spring effectiveness of the plantar arch during running;

(5) the permanent inability to oppose the hallux to increase stability during plantar flexion;

(6) relatively short phalanges adding to improved lever function.

Based on the functional anatomy of the foot: two segments comprising the longitudinal arch

1. medial column of the foot (calcaneus, talus, tarsal navicular, cuneiform 1 to 3, and metatarsal 1 to3)
2. lateral column of the foot (calcaneus, cuboid, and metatarsals 4 and 5

Although foot injuries are not life threatening, they have significant impact on the activity of daily living of the patient

Fractures of the forefoot are common and may result in significant sequelae. The forefoot as unit provides a broad plantar surface for load sharing.

This platform also is structured to be mobile in the sagittal plane and provides the forefoot with the ability to alter the position of the individual metatarsal heads to accommodate uneven ground.

Therefore, injuries to this area can lead to difficulties with ambulation and gait. Although the forefoot appears to work as a single unit, its parts are distinctly different and need to be treated accordingly in the case of injury.

LITERATURE REVIEW:

In 1995 MK O'Shea et al[1] presented a retrospective study of fifth metatarsal fractures including Jones fractures, avulsion fractures, spiral and oblique midshaft fractures, and the author-termed "tulip" fracture (impaction fracture of the fifth metatarsal head). These fractures were fixed with the cannulated screw, Kirschner wires, and circlage loop wires combined with Kirschner wires. A one-way analysis of variance (ANOVA) was performed on the data to test for any significant difference in the fixation type used and the overall healing time. The ANOVA was found to be nonsignificant, $F(2,10) = 0.379$, $p < 0.05$. Therefore, it can be concluded that all three types of fixation work equally well.

In 1996 Martin J. O'Malley[2],et al reported Spiral fractures of the distal shaft of the fifth metatarsal are common injuries and can usually be treated nonoperatively for these high performance athletes without long-term functional sequelae.

In 2012 Hyong-Nyun Kim, MD et al[3] reported Closed antegrade intramedullary pinning was found to be a useful method for treating

displacedmetatarsal fractures and to allow immediate joint motion and partial weightbearing in a stiff-soled shoe.

In 2012Daniel Baumfeld et al[4]**:** described Anterograde percutaneous treatment of lesser metatarsal fractures. They concluded thatPercutaneousantegrade surgical treatment is an effective alternative to other types of treatment for lateral metatarsal fractures, with a lower incidence of complications.

In 2016 Mahan, Susan T et al[5]study was to review multiple metatarsal fractures to help refine surgical indications. A total of 98 patients had multiple metatarsal fractures; displacement greater than 10% shaft width (displaced) was encountered in 33 (34.0%) patients. Fifteen patients had displacement of more than 75% shaft width of one metatarsal. Patients older than 14 years of age were more likely to have surgery for their injury (52.6%) than those younger than 14 years of age (3.7%) (P<0.0001). Younger patients and those with less than 75% displacement should be considered for no operative care.

METATARSAL FRACTURES

Definition:

A metatarsal bone fracture is a complete or incomplete break in one of the five metatarsal bones in each foot. These long thin bones are located between the toes and the ankle (between the tarsal bones in the hindfoot and the phalanges in the forefoot).

Epidemiology:

The metatarsals are a common fracture site in the body and account for 35% of all foot fractures [6].Metatarsal fractures occur most often in patients between 20 and 50 years of age.5 to 6% of fractures treated in primary care are metatarsal fractures. These are the most common injuries of the foot. They are about ten times as frequent as Lisfranc-dislocations.They are equally among men and women .

The distribution of the fractures[6]:

- First metatarsal: 5%
- Second metatarsal: 12%
- Third metatarsal: 14%

- Fourth metatarsal: 13%
- Fifth metatarsal: 56%
- Multiple metatarsal fractures: 15.6%

Metatarsal fractures are common in the pediatric age group, accounting for close to 60% of all pediatric foot fractures[7]. The most common involved fracture in childhood is fifth metatarsal [8]followed by the third metatarsal. The lowest rate is in first metatarsal. Children age below the 5 years are more likely to have first metatarsal fractures, with a frequency of isolated first metatarsal fractures of 51%, in contrast to those more than 5 years old, who are more likely to have fifth metatarsal fractures, depending on the age group, a frequency as high as 65%[8]. The next most common fracture finding was a specific combination of second, third and fourth metatarsal fractures[8][9][10][11]..

Metatarsal fractures may result from direct or indirect violence, and they display a wide variety of injuries ranging from isolated, simple fractures of one metatarsal to crush injuries with serial fractures and severe soft tissue compromise. Direct trauma is common in industrial workers where they have a heavy object fall on the foot. Indirect trauma happened when the leg and hindfoot are twisted with the forefoot fixed.

Injury to the metatarsals is common in acute and chronic settings and they are the most common site for stress fractures in the human skeleton[12][13][14][15].. Among stress fractures of the metatarsal bones, the middle and the distal portions of the corpus ossismetatarsalis II or III are most common. Stress fractures at the base of the first or second metatarsals are less common[16].. Metatarsal stress fractures are a common in athletes, particularly in runners, in whom they account for 20% of lower extremity stress fractures. Increased stresses over the second and third metatarsals during walking and running, these metatarsals are at greatest risk for stress fracture.[17][18].

The percentages ofinjuries as follows[6]:

- Supination injury: 48%
- Fall from height: 26%
- Crush injury: 12%

Athletes, individuals who are obese, and with osteoporosis or rheumatoid arthritis or diabetes have an increased risk of getting metatarsal fractures.

It also occurs in sports like jogging, ballet, gymnastics, and high-impact aerobic activities[18]. Shoe shock attenuation will prevent the metatarsal stress fractures[19].

It has been shown that the fracture pattern and severity of injury vary according to age and mechanism of injury[20].This association can further be correlated with both osseous development and the age-related levels of activity[10].

The metatarsal can be fractured at 3 locations: on the caput, corpus or on the basis ossis metatarsalis. Like that we can differentiate multiple different fractures:

- Sub capital fracture.
- Fracture of the corpus ossis metatarsalis.
- Fracture of the basis ossis metatarsalis.

The arterial arch and the dorsal and plantar metatarsal arteries are more susceptible to injuries in associated with metatarsal fractures. Compartment syndrome is common with soft tissue trauma in the metatarsal region.

FUNCTIONAL ANATOMY:

First Metatarsal Fractures

Pathoanatomy and Applied Anatomy Relating to

First Metatarsal Fractures

The first metatarsal is stronger than the other 4 metatarsals. It accounts for 1.5% of all metatarsal fractures[21].. Its has large cross-sectional geometric properties and its role as the preferred ray for loading during walking, running or turning in a different direction[22].. Its configuration is shorter and wider than the lesser four metatarsals. The lack of interconnecting ligaments allows independent motion between the first and second metatarsal.

There are two powerful muscle attachments to its base. The tibialis anterior inserted on the plantar surface of medial aspect of the first metatarsal base and the peroneus longus inserted onto the plantar surface lateral base of the first metatarsal. These muscles exert significant influence on the position of the head of 1st metatarsal. Averagepeak pressures in metatarsal 1 are the highest or among the highestlevels of pressure during most activities[23].

First Metatarsal Injury Mechanisms:

First metatarsal fractures can occur from direct or indirect forces. Direct injuries are common in industrial workers. heavy object falling on the foot. Indirect injuries occurs, when the forefoot fixed and the leg or foot is twisted.[12]

First Metatarsal Fracture Imaging:

Three xrayviews are mandatory to judge

- shortening,
- deviation
- angulation,
- displacement

intra articular fracture lines and fragments can be seen through computed tomography. MRI needed for additional information related to soft tissue injuries.

First Metatarsal Fracture Classification:

The OTA classification:

TYPE A: extra articular simple fractures

TYPE B: partial articular involvement or wedge fracture of shaft

TYPE C: complete articular involvement or comminuted shaft fractures

First Metatarsal Fracture Treatment Options:

Nonoperative Treatment:

No evidence of instability on stress films of the fracture, and no other injuries of the midfoot and metatarsals and isolated minimally displaced first metatarsal fractures can be treated non operatively byshort-leg cast with non weight bearing for 3 weeks then additional 3 weeks with weight bearing as tolerable

Operative Treatment of First Metatarsal Fractures.:

Evidence of instability or loss of position of the metatarsal head should be treated with operative stabilization.

Goal of the treatment:

To restore and maintain the normal position of thatmetatarsal head, the sesamoids, and metatarsophalangeal joint.

The method of fracture fixation is dependent on fracture configuration.

Percutaneous smooth wires: simple and reducible fractures

Open reduction and internal fixation is needed for: displaced fractures Simple spiral or oblique fractures: open reduction and lag screw fixation with 2.7mm screws.

If tarso metatarsal joints are unstable can betreated with contoured one third plate extend between medial cuneiform and distal intact metatarsal shaft.

Plate and screw fixation used for transverse or minimally comminuted fractures (fig 3). in which inadequate fixation will occur with screws or wires alone.

External fixation can be considered if there is severe midshaft or head comminution or open injuries(fig 4). These fracture types usually have significant soft tissue.

Fig 3: : 1st metatarsal shaft fractures treated with plating

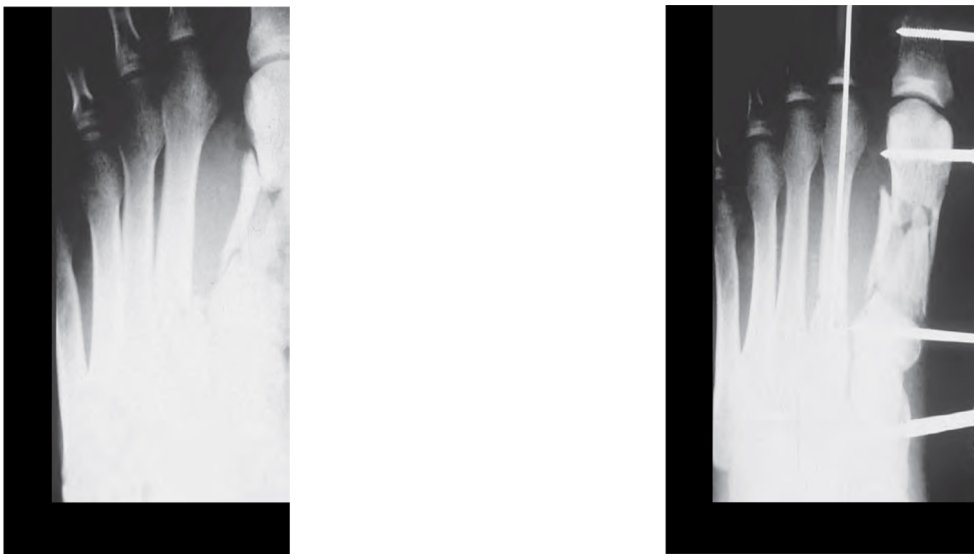


Fig 4: 1st metatarsal comminuted shaft fractures treated with external fixation.

CENTRAL METATARSAL FRACTURES:

Fractures of the central metatarsals account for approximately 10% of all metatarsal fractures Fractures of the central metatarsals are much more common than first metatarsal fractures[10].

Central metatarsal fractures can occur from direct or indirectforces. Direct injuries are common in industrial workers and occur as a result of a heavy object falling on the foot. Indirect injuries are seen in sport, when the forefoot is fixed and the leg or foot is twisted Central metatarsal fractures also occur as stress fractures. Central metatarsals fractures are commonly associated with injuries to the first ray, and Lisfranc joint injuries.

The 2nd and 3rd metatarsals are more important because they comprise the keystone of the foot.The metatarsal bases are of trapezoidal shape. It forms a "Roman arch" configuration. Base of each central metatarsal having series of three ligaments (dorsal, central, and plantar), they stabilize and support each with their neighbour.

MANAGEMENT:

Any fracture displacingmore than 10 degrees of deviation in the sagittal plane or 3 to4 mm of translation in any plane should be actively corrected. Majority of isolated central metatarsal fractures can be treated nonoperatively. Isolated head or neck fractures that deviateeither dorsally or plantarly in the sagittal plane are treated with closed reduction using finger trap distraction to restore

the normal alignment. A stable fracture of the base of the third or fourth metatarsal can be reduced closed without fixation. Hyperextended distal metatarsal fractures may cause dislocation with the head comes through the flexorplaten can prevent closed reduction.

OPERATIVE TREATMENT OF CENTRAL METATARSAL FRACTURES:

Indications :

Unstable base fracture of the second metatarsal requires

Multiple adjacent metatarsal fractures

Severe comminuted fractures

Hyperextended neck fractures

Indication for surgery according to shereff:

Evaluation	Parameters
Frontal plane	> 3 to 4 mm of deviation
Sagittal plane	Angulation > 10 degrees
Metatarsal formula	Changes in the metatarsal parabola

Method of fixation based on fracture pattern:

open reduction and plate fixation: comminuted oblique shaft fractures and transverse fractures

Interfragmentary compression screw : Oblique fracture in diaphyseal region

Intramedullary K-wire fixation : If there is significant soft tissue injury or open wound, K-wire fixation performed. K-wire fixation is also effective if there is severe comminution of the shaft fractures . One should be careful not to shorten the position of the head in relation to its neighbors.

Fifth Metatarsal Fractures

Pathoanatomy and applied anatomy relating to fifth metatarsal fractures:

The base of the fifth metatarsal is a complex anatomic region withthe insertion of three muscles. The peroneus brevis inserted on the dorsal aspect of the tubercle of the fifth metatarsaland the peroneus tertius inserted on the dorsal aspect at theproximalmetaphyseal-diaphysealjunction.Peroneustertius muscle acts as a balancing force during forefoot dorsiflexioncounteracting the natural inversion tendency of thetibialis anterior. The peroneus brevis act as more of an antagonist to posterior tibialis function to maintain the position. The third one is the abductor digitiquinti. It has a strong attachment of the plantar fascia to the plantar aspect of the tubercle.

The blood supply to the proximal fifth metatarsal at the

Metaphyseal-diaphyseal junction has been implicated as the leadingcause for the development of a delayed union or nonunion infractures of the proximal fifth metatarsal. Fifth metatarsal fracture account for 68% of all metatarsal fractures.

Fig 5: Locations of fracture zones for proximal fifth metatarsal fractures

Fifth Metatarsal Fracture Injury Mechanisms:

Majority of injuries are due to twisting of thefoot or a fall from a standing height.

zone 1 injury usually occurs from an indirect load. Sudden inversion of the hindfootwithweight placed on the lateral metatarsalproduce tension along the insertion of the lateral band of the plantar aponeurosis which insertsinto the proximal base of the fifth metatarsal causing avulsion fracture.

Zone 2 injury is the true Jones fractures caused by adduction of the forefoot will produce a fracture at the proximal metaphyseal–diaphyseal junction of the bone.

Zone 3 fracture seen in the proximal fifth metatarsalis now referred to as a proximal diaphyseal stress fracture.These fractures are rare and seen mainly inathletes. It mainlyoccurs in the proximal 1.5 cm of the metatarsal shaft.

SPECIFIC CAUSES OF FRACTURES:

Most fractures of the corpus ossismetatarsalis are caused by direct blows or twisting forces. An abrupt increase in activity or chronic overload may cause a stress fracture of the metatarsal corpus.

The most common mechanism of injury in fifth metatarsal fractures involves a fall from standing height or an ankle twist with the forefoot fixed.

An avulsion fracture of the fifth metatarsal base (‘tennis fracture’) may occur as a result of inversion injuries to the foot, seen that the base of the fifth metatarsal is the endpoint of the ‘supination fracture line’.

A tuberosity avulsion fracture usually results from ankle inversion while the foot is in plantar flexion. The history often suggests a lateral ankle sprain, and these fractures are often missed.

A diaphysial stress fracture is often due to a chronic overloading, especially from jumping and pivoting activities in younger athletes.

Fractures from the first through the fourth metatarsals are the kind of fractures that are less common than other metatarsal fractures. They warrant special consideration, because they are often associated with injury to the Lisfranc ligament complex. These crucial ligaments hold the metatarsal bases rigidly in place, maintaining the arch of the foot and anchoring the metatarsals to the rest of the body.

Proximal metatarsal fractures are usually caused by crush injuries or direct blows. They may also result from falling forward over a plantar-flexed foot. In athletes, the most common mechanism for a Lisfranc injury is an axial load placed on a plantar-flexed foot.

Characteristics/ clinical presentation:

Symptoms and signs are:

- Painful and swelling
- Palpable crepitus
- Axial pressure pain

Patients with metatarsal fractures complain of pain on ambulation and inability to weight bear. The forefoot is swollen and tender to palpation. Gross deformities are mainly present with complex injury patterns including multiple fractures and additional toe dislocations.[23]

shaft fractures: Typically presents with pain, swelling, ecchymosis and difficulty walking. Initially the pain only occurs with activity. Swelling is severe if the patient has not elevated the foot. Point tenderness over the fracture site. Applying an axial load to the head of a metatarsal usually triggers pain at the injury site. Patients with soft tissue injuries shouldn't experience pain with this maneuver.

Tuberosity avulsion fracture, Jones fracture and diaphyseal stress fracture: These fractures cause lateral foot pain and difficulty walking. Acute fractures also have a sudden onset of swelling and ecchymosis. Stress fractures usually cause a progressive increase in pain which is worsening

with activity. Recognizing the gradual onset of symptoms is key to correctly diagnosing fifth metatarsal stress fractures.[19]

Stress fractures: Early signs are: pain increased during activity that relieved with resting and pain over a wide area of the foot. Over time the pain will be present constantly and stronger in one area of the foot. The area of the foot where the fracture is may be tender when you touched. It might be swollen as well.

Diagnostic Procedures

A physical examination of the foot with x-rays and bone scans are used to diagnose the fractures of metatarsal. When the patient having a typical history and appropriate physical findings, a presumptive clinical diagnosis can be made. Routine X-rays (anteroposterior, lateral and oblique) are sufficient to diagnose the fracture. A CT-scan or MRI is used to exclude other injuries when it isnecessary. When a stress fracture is expected a bone scan may be helpful.

Acute metatarsal fracture (fracture metatarsal shaft) Radiographic findings: Fracture position and pattern can be assessed by two views that lie at a 90° angle to each other. Oblique or modified lateral views are often more helpful. Fracture lines may not be visible on initial xrays. In this case

the clinical examination and the radiographs should be repeated after one to two weeks of initial injury.

Fractures of the proximal first through fourth metatarsals (figure 6): Radiographic findings: Proximal fractures are commonly transverse or oblique and sometimes multiple. In case of Lisfranc ligament injury a standard radiographic series may be normal in fifty percent of the patients. In this case weight-bearing anteroposterior and lateral radiographs should be taken: the anteroposterior view showswidening of the space between the first and second metatarsal heads (stage II or III) with loss of arch height on the lateral view in stage III injuries. Radionuclide bone scan: is accurate for diagnosis in case of stage I injury with clinical suspicion and normal radiography.

Figure 6 : Nondisplaced fractures of the proximal portions of

Metatarsal 2 – Metatarsal 4.

Acute fractures of the proximal fifth diaphysis : Using the Ottawa ankle rule we can exclude a lateral ankle sprain from a tuberosity avulsion fracture. When point tenderness is present over the fifth metatarsal and the foot appears to be normal, it could be a sprain.

Jones fracture: fig 7: Radiographic findings: Acute fracture of junction between the proximal diaphysis and the corpus ossis metatarsi quinti. The fracture line is sharp and extends into the joint between metatarsal 4 and metatarsal 5. A jones fracture can be a stress fracture or an acute break.

Fig 7:Jones fracture

Tuberosity (styloid) fracture : (fig 8:)Clinical findings: A radiolucency is seen perpendicular to the long axis of the 5thMetatarsal. The fracture may be intraarticularorextraarticular (cuboid-metatarsal articulation) and never extend into the joint between the fourth or fithmetatarsal (=different from Jones fractures). It involves the tip of the styloid process at the attachment of the plantar aponeurosis and peroneus brevis. The peroneus brevis tendon has a broad lateral insertion and may cause further dislocation .[26]

Outcome measures:

1) Acute metatarsal fracture :

Favourable:

Displacement is often minimal unless more than 1 Metatarsal is injured, Fractures of a single Metatarsal shaft with lateral or medial displacement usually heal well without correction.[19]

Unfavourable:

Displacement of more than 3mm or 4mm displacement in a dorsal or plantar direction or dorsal /plantar angulation exceeds 10 degrees need reduction. Skin necrosis- due to crush injury- leading to an open fracture.

2) Fractures of the proximal first through fourth metatarsalsInjury to the Lisfranc ligament complex can cause chronic disability. [19]

3) Acute fractures of the proximal 5th diaphysis: Jones fractures

With conservative treatment, patients frequently complain about the lenght of time for nonweight bearing and pain following the first weeks of rehabilitation as delayed union is surprisingly common. Complications like nonunion and refracture are reported in literature, but often conservative treatment is the first option in common population. [19]

4) Tuberosity (styloid) fracture :

Nondisplaced avulsion fractures usually heal well within 30 to 40 days with symptomatic therapy.

When the fracture is greater than 3 millimeters of displacement or a step-off of more than one to two millimeters on the articular surface with the cuboid, surgical treatment is needed. [19]

5)Stress fracture

Stress fractures of the metatarsal shaft usually heal well in case of discontinuation of the causative activity for 4 to 8 weeks.After 4 to 8 weeks pain typically reduced [19]

CONSERVATIVE MANAGEMENT:

NON-DISPLACED FRACTURE OF THE CORPUS OSSIS METATARSI:

- first 24 hours: ice and elevation (higher than the heart). Progressive weight bearing and treating with soft elastic dressing or a firm supportive shoe
- immobilization in a posterior splint and 3 to 5 days non-weight bearing

DISPLACED METATARSAL FRACTURES:

Displaced more than 3 to 4mm in dorsal or plantar direction:

First 24 hours: ice and elevation (higher than the heart)

Reduction: under local anesthesia, using a regional or hematoma block. Placing the toes in Chinese finger traps and allowing gravity to accomplish the reduction. The reduction should be maintained in a molded, bivalve, below knee cast and postreduction radiographs should be obtained to confirm proper alignment.

Stress fractures of the metatarsal shaft:

Responds well to cessation of the causative activity (4 to 8 weeks)

Walking causes pain? Crutches and partial-weight bearing

Walking causes severe pain? Non weight-bearing, short leg cast (1 to 3 weeks)

METATARSAL 5 fracture:

Tuberosity Avulsion:

Symptomatic therapy (3 to 6 weeks)

- soft protective dressing

- short leg cast

Too symptomatic

- a hard-soled shoe or wood-soled postoperative brace or cast

Jones fracture = dancer's fracture:

- non-weight bearing cast (6 to 8 weeks), crutches are required

- weight bearing orthosis (8 to 12 weeks)

METHODOLOGY:

AIM OF THE STUDY:

- To compare and evaluate the results of surgical treatment of multiple metatarsal fractures (> 1 Metatarsal involved) using “Kirschner” wire fixation and plate osteosynthesis

INCLUSION CRITERIA:

- Multiple metatarsal fractures- > 1 Metatarsal involved
- Simple fracture
- Open fractures grade I
- Age More than 16 yrs

EXCLUSION CRITERIA:

- Grade II and III open fractures
- Single metatarsal
- Un co-operative pts(mentally ill)
- Associated lower limb long bone fractures
- Age less than 16 yrs

MATERIALS AND METHODS

In this study, we have operated on 15 patients after excluding patients according to the exclusion criteria. We included only multiple metatarsal fractures.

In this study we selected the patients through randomization by tossing a coin. After randomization, patients were assigned to the 2 groups – one group undergoing open reduction and internal fixation with plate osteosynthesis; other group undergoing Kirschner-wire fixation.

Informed consent was taken from all patients. Surgery was done electively after assessment under regional anaesthesia. All cases were taken up for surgery immediately following admission.

Source of Data

Patients with multiple metatarsal fractures simple and compound grade admitted at Govt. Rajaji hospital in the department of orthopaedics& traumatology Madurai were taken up for study after obtaining informed consent. All the patients selected for study were examined according to protocol, associated injuries were noted and clinical and lab investigations carried out in order to get fitness for surgery. Consent of the patient was obtained for surgery. Patients were followed till **good**

functional out come is achieved **Clinicaly** as well as **Radiologically. 15 cases were** studied.

- **Pre operative preparation:** Patients underwent a pre-operative evaluation including the following parameters : Hb, blood sugar, ECG, RFT ,x ray chest inorder to get fitness for surgery

- FOLLOW UP PERIOD:

AT 3 days

AT 2 weeks

AT 1 ½ month

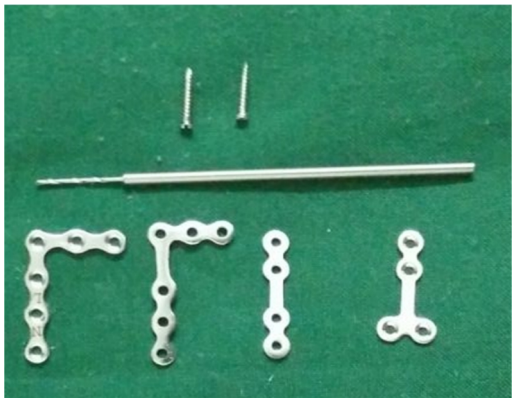
AT 3 month

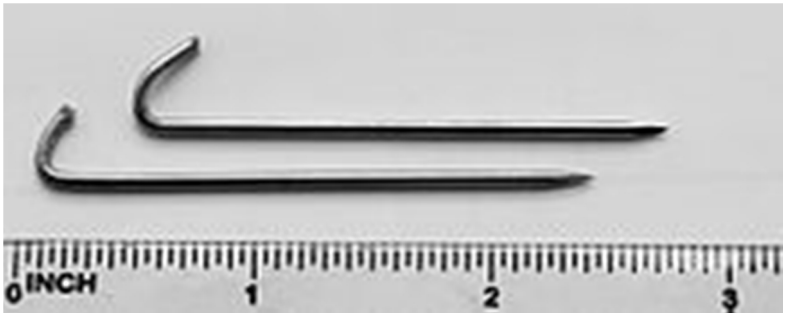
AT 6 months

AT 12 months

- Kirshnerwire removal at the period of 6 – 10 weeks
- Plate removal after 1 yr

IMPLANTS AND INSTRUMENTS:





Anaesthesia:

General anaesthesia or spinal anaesthesia or ankle block

surgical technique:

- Antegrade kirshner wire fixation under radiological control.
- Open reduction and internal fixation Mini plate system.

surgical approach:

APPROACH- DORSAL APPROACH FOR METATARSALS

- The veins are superficial and should be preserved
- The approach is in between the long and the short extensor tendons, staying lateral to the EDL.
- Branches of the deep peroneal nerve must be identified and protected

Skin incision

- The skin incision is made in line with the first ray, starting over the medial cuneiform and extending to the dorsolateral aspect of the first proximal phalanx.

Deep dissection

- Expose the first metatarsal between the tendons of extensor hallucislongus and hallucisbrevis
- Take care to protect the dorsalispedis artery and the cutaneous branches of the deep peroneal nerve.

Dorsal approach to 2^{nd} 3^{rd} 4^{th}metatarsals:

Skin incision

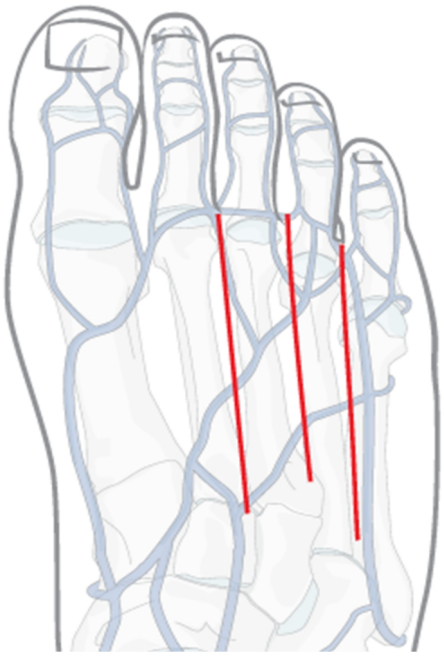
- Make a longitudinal incision between the second and the third metatarsal extending it from the metatarso-phalangeal to the tarsometatarsal joint.

- Make a longitudinal incision along the dorsolateral aspect of the 4th metatarsal, from the head to the tarso-metatarsal joint.

Multiple incisions:

- If all lesser metatarsals (2, 3, 4, and 5) are to be approached, we would advocate three incisions: one between the 2nd and 3rd, the second between the 3rd and 4th and the third between the 4th and 5th.

- DORSAL INTERMETATARSAL APPROACH



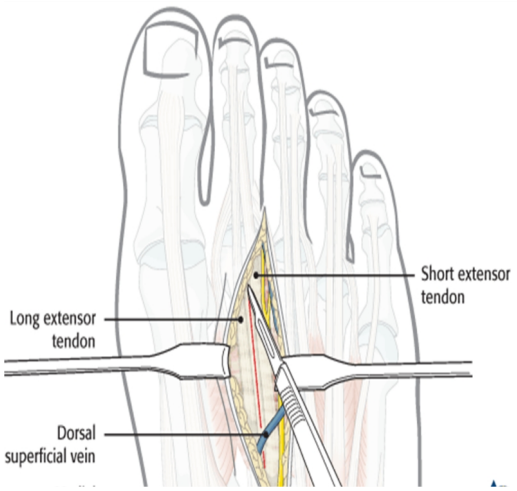
- ***Deep dissection***

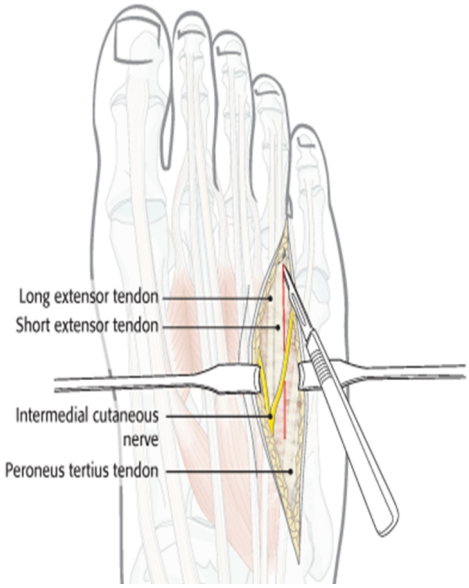
- Approach goes in-between the long and the short extensor tendon of the corresponding ray.

- Should protect the intermetatarsal nerves and the crossing superficial veins

- For this approach no muscle must be incised. Eventually, the interosseous musculature might be detached locally.

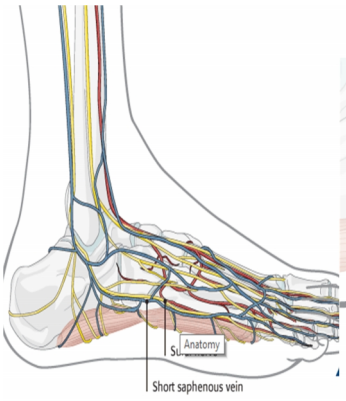
- DEEP DESSECTION

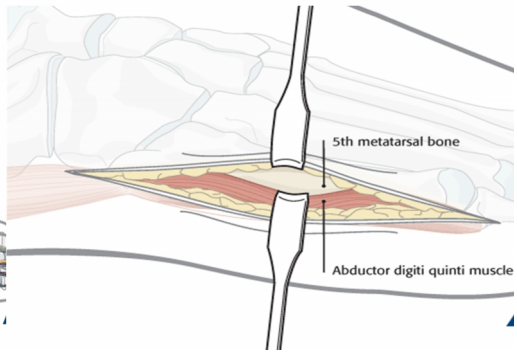
- 



- **Lateral approach to the 5th metatarsal:**

- **Skin incision:**
- The incision is made at the junction of the dorsal skin and the plantar skin
- The skin incision starts just proximal to the styloid process of the base of the fifth metatarsal and proceeds distally, as far as required.
- **Deep dissection:**
- Expose of the fascia over the abductor digiti muscle belly, and incise it longitudinally.
- Retract the skin and fascia dorsally, and the muscle belly in a plantar direction, exposing the underlying fifth metatarsal.
- LATERAL APPROACH: DEEP DISSECETION





AOFAS MID FOOT SCALE (100 points total)

(AMERICAN ORTHOPAEDIC FOOT AND ANKLE SCORE)

The surveys include a mixture of questions that are both subjective and objective in nature. The pain category which asks patients a single question about their level of pain is subjective, while the alignment category (to be answered by the physician) is objective.

EXCELLENT = 90 -100 POINTS

GOOD = 90-80 POINTS

FAIR = 80- 70 POINTS

POOR = < 70 POINTS

PAIN (40 points)	
None	40
Mild, occasional	30
Moderate daily	20
Severe almost always present	0
FUNCTIONS: (45 POINTS) **Activity limitations , support:**	
No limitations ,no support	10
No limitations of daily activities, limitations of recreational activities, no support	7
Limited daily and recreational activities, cane	4
Severe limitations of daily and recreational activities, walker, crutches , wheelchair	0
FOOT WEAR REQUIRMENTS:	
Fashionable, conventional shoes, no insert required	5
Comfort footwear , shoe insert	3
Modified shoes or brace	0
MAXIMUM WALKING DISTANCE, BLOCKS	
Greater than 6	10
4 – 6	7
1 – 3	4
Less than 1	0
WALKING SURFACES	
No difficulty on any surface	10
Some difficulty on uneven terrain, staires, inclines, ladder	5
Severe difficulty on unev0en terrain, staires, inclines, ladder	0
GAIT ABNORMALITY	
None , slight	10
Obvious	5
Marked	0
ALIGNMENT(15 points)	
Good plantigrade foot, mid foot well alighned	15
Fair plantigrade foot. Some degree of midfootmalalignment observed no symptoms	8
Poor plantigrade foot, severe malalignmant, symptoms	0

CASES:

CASE 1:

SERIAL NO: 1

NAME: RAMAKRISHNAN

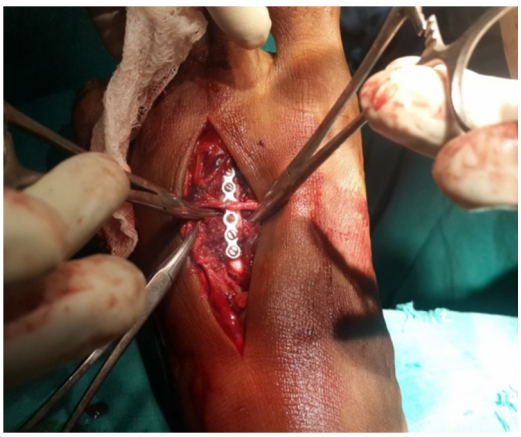
AGE/SEX: 18/M

DIAGNOSIS: # METATARSAL 2^{ND} 3^{RD} LEFT SIMPLE

PREOP:


L
Foot AP/OBL
RAMANARAYANAN 17YRS
CR 770709
Foot AP/OBL
08/10/2016 5:32:39 PM

INTRA OP:



POST OP:

Follow up xray:

Follow up clinical photo:

CASE : 2

SERIAL NO: 2

NAME: RAMESH

AGE/SEX: 43/M

DIAGNOSIS: # METATARSAL 2^{ND} 3^{RD} RT SIMPLE

PREOP:

POST OP:

3M0NTH POST OP:

6 MONTH POST OP:

CASE :3

SERIAL NO: 3

Name : karupaya

Age /sex: 63/m

Diagnosis : # METATARSAL 2nd ,3rd lt foot comp.

Preop xray:

Intraop photo:

Post op:

Postop clinical photo:

Post operatively wound got infected and implant exit was done.

CASE:4

SERIAL NO: 5

Name : Eswari

Age/sex: 35/f

Diagnosis: # metatarsal 3rd 4th 5th comp grade 1 right foot

Pre op:

Post op:

Follow up xray:

Clinical photo:

CASE: 5

SERIAL NO: 6

NAME: KALIDOSS

AGE/SEX: 23/M

DIAGNOSIS: # METATARSAL 2^{ND} 3^{RD} SIMPLE

PRE OP:

POST OP:

1 ½ MONTH POST OP:

Surgical site was infected and treated with intravenous antibiotics

Follow up xray:

: 

CLINICAL PHOTO:

Case :6

SERIAL NO: 7

Name : santhana pandy

Age /sex: 18/ m

Diagnosis : # metatarsal 1st 2nd 3rd left foot simple

Pre op xray:

intra op photos:

Post op xray:

Follow up xray:

Final follow up:

Clinical photo:

Case: 7

SERIAL NO: 8

NAME: MUTHURAJA

AGE: 51/M

DIAGNOSIS: # METATARSAL 3RD 4TH COMP.

PRE OP: POST OP:

FOLLOWUPxray :

CLINICAL PHOTO:

Case: 8

SERIAL NO: 9

Name :Aravindsamy

Age /sex: 23/m

Diagnosis : # metatarsal 2nd 3rd simple

Pre op:

Post op:

Follow up xray:

Final follow up:

CASE : 9

SERIAL NO: 10

NAME : CHOCKALINGAM

AGE/SEX: 40/M

DIAGNOSIS: # METATARSAL 2^{ND} 3^{RD} RT COMP.

PRE OP:

POST OP

1 ½ MONTH FOLLOW UP:

3 MONTH FOLLOW UP:

6 month follow up:

Clinical photo:

CASE : 10

SERIAL NO: 11

Name : kannan

Age /sex: 32/m

Diagnosis : # metatarsal 1^{st} 2^{nd} 3^{rd} 4^{th} comp injury right

Pre op xray:

post op xray:

3 month follow up:

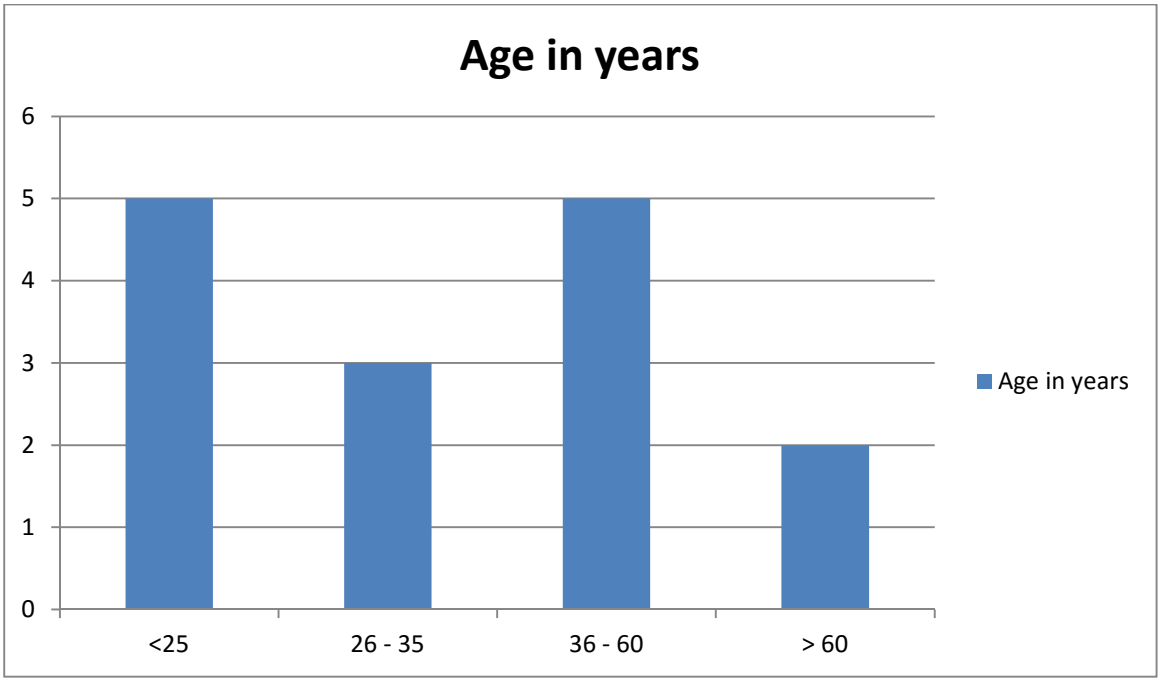
Follow up xray:

Clinical photo:

STATISTICS

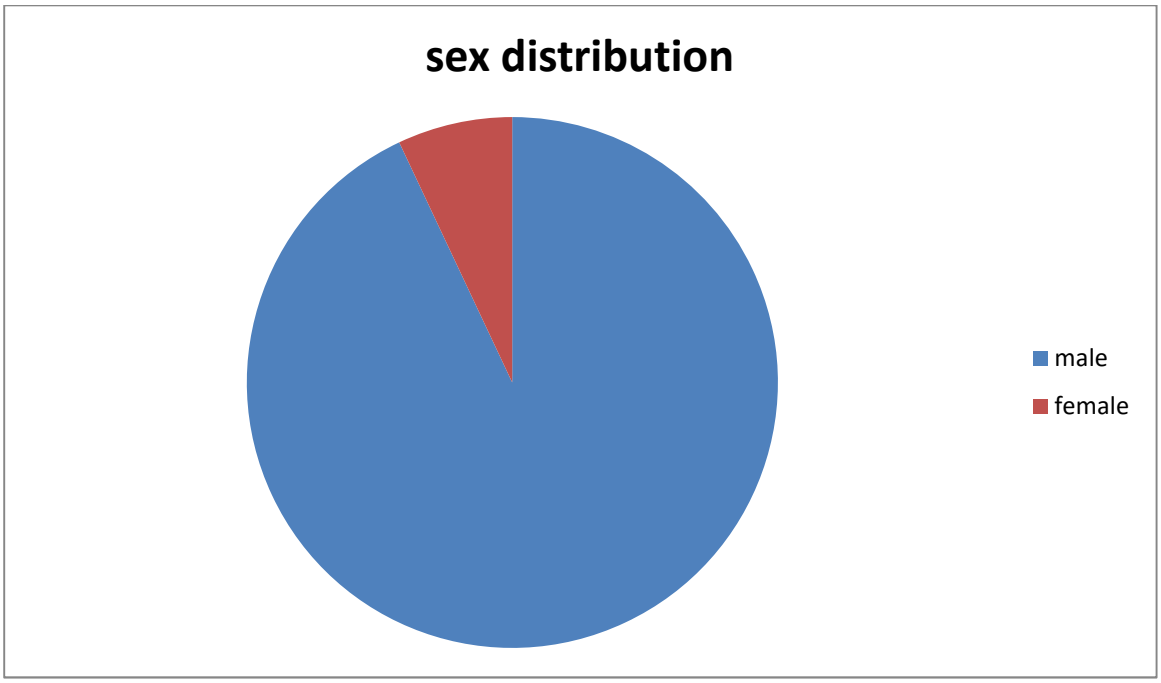
I. AGE DISTRIBUTION

Age in years	No. of cases	Percentage
<25	5	33
26 – 35	3	20
36-60	5	33
>60	2	14



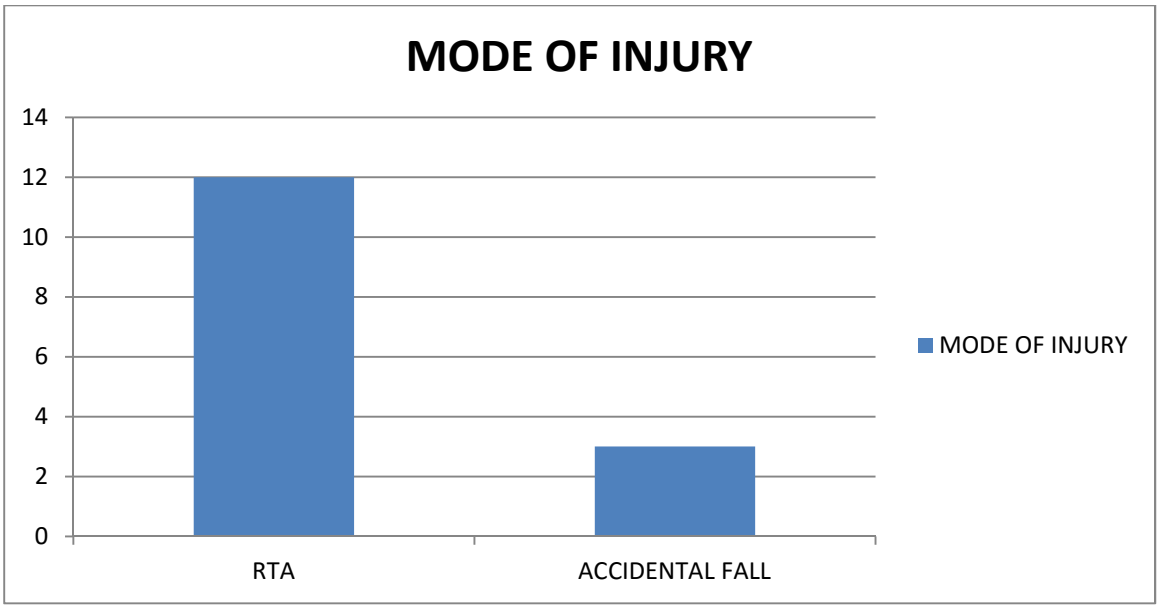
II. SEX DISTRIBUTION

Sex	No. of cases	Percentage
MALE	14	93
FEMALE	1	7
TOTAL	15	100



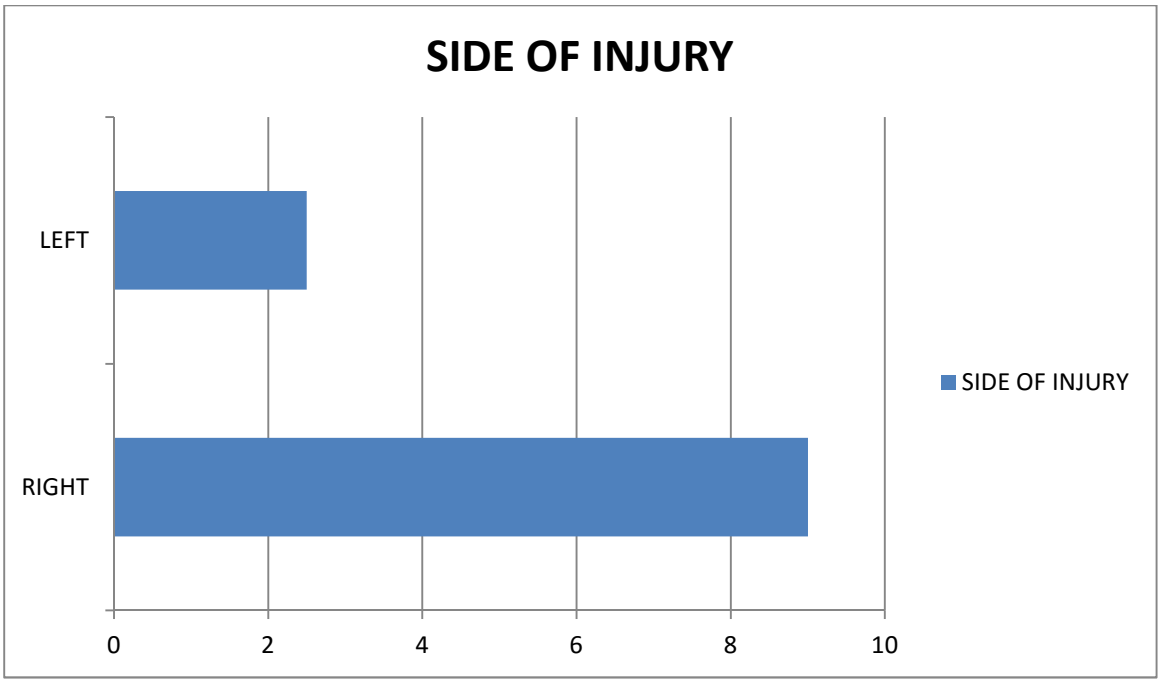
III. MODE OF INJURY

Mode of injury	No. of cases	Percentage
RTA	12	80
ACCIDENTAL FALL	3	20
TOTAL	15	100



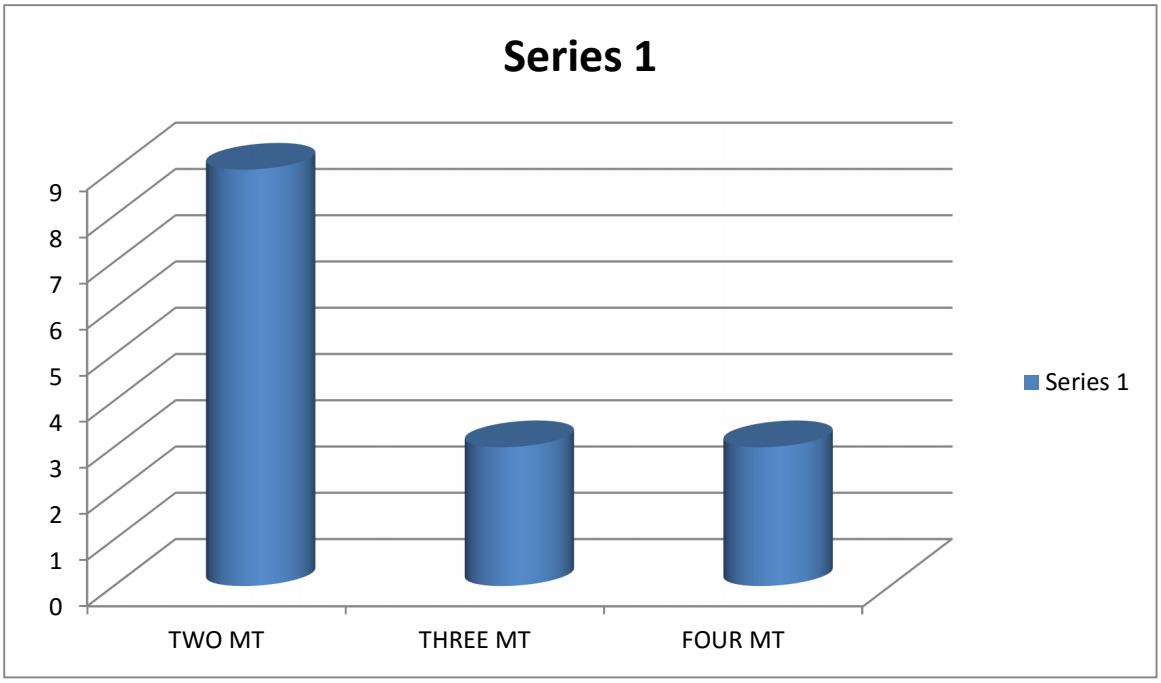
IV. SIDE OF INJURY

SIDE	NO.	PERCENTAGE
RIGHT	9	60%
LEFT	6	40%
TOTAL	15	100%



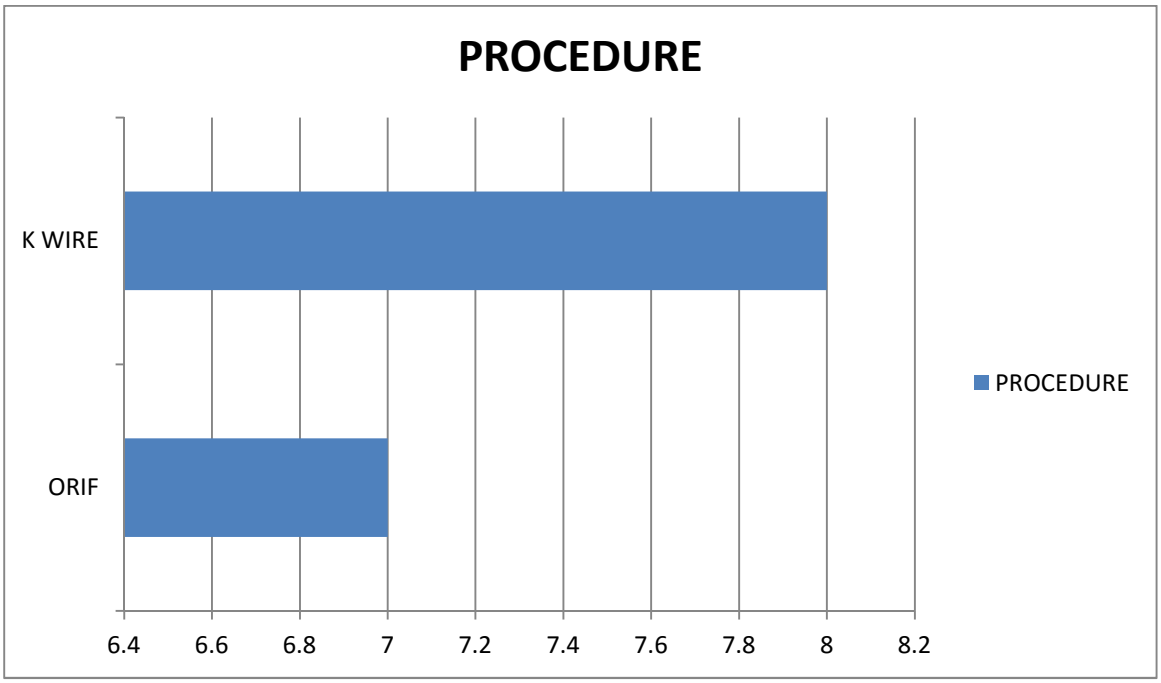
V. METATARSALS INVOLVED

No of metatarsals involved	No.	Percentage
2	9	60%
3	3	20%
4	3	20%



VII.PROCEDURE

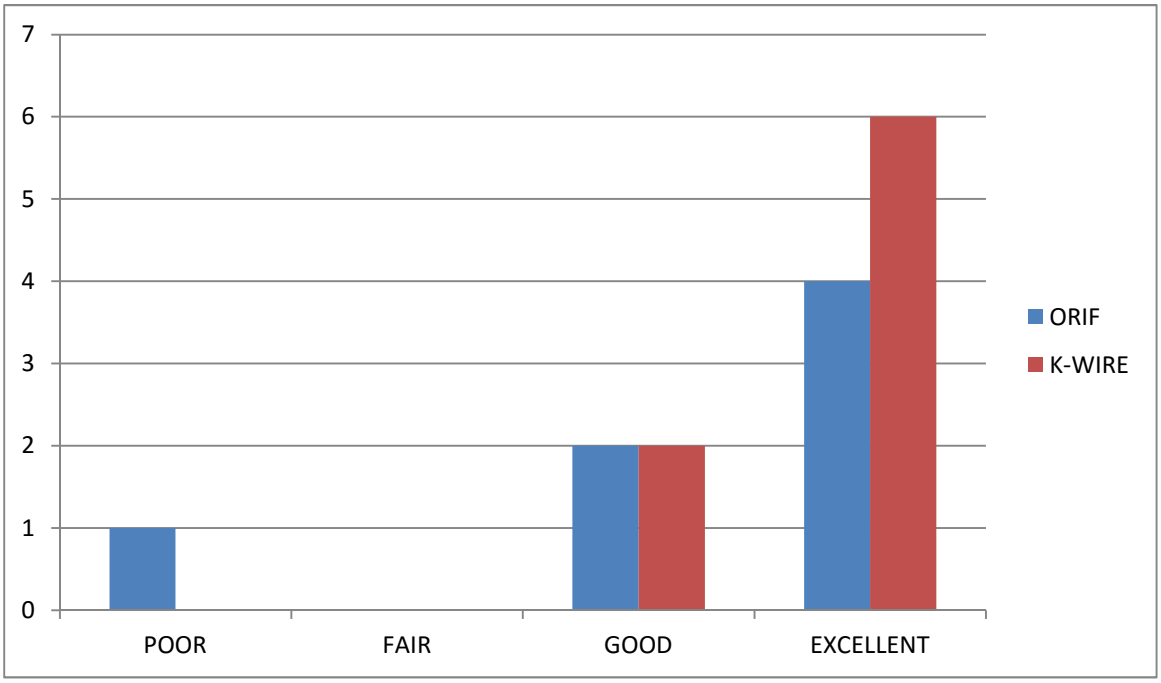
SURGERY DONE	NO.
ORIF WITH PLATE OSTEOSYNTHESIS	7
KIRSCHNER WIRE FIXATION	8



VI. AOFAS SCORE AND OUTCOME

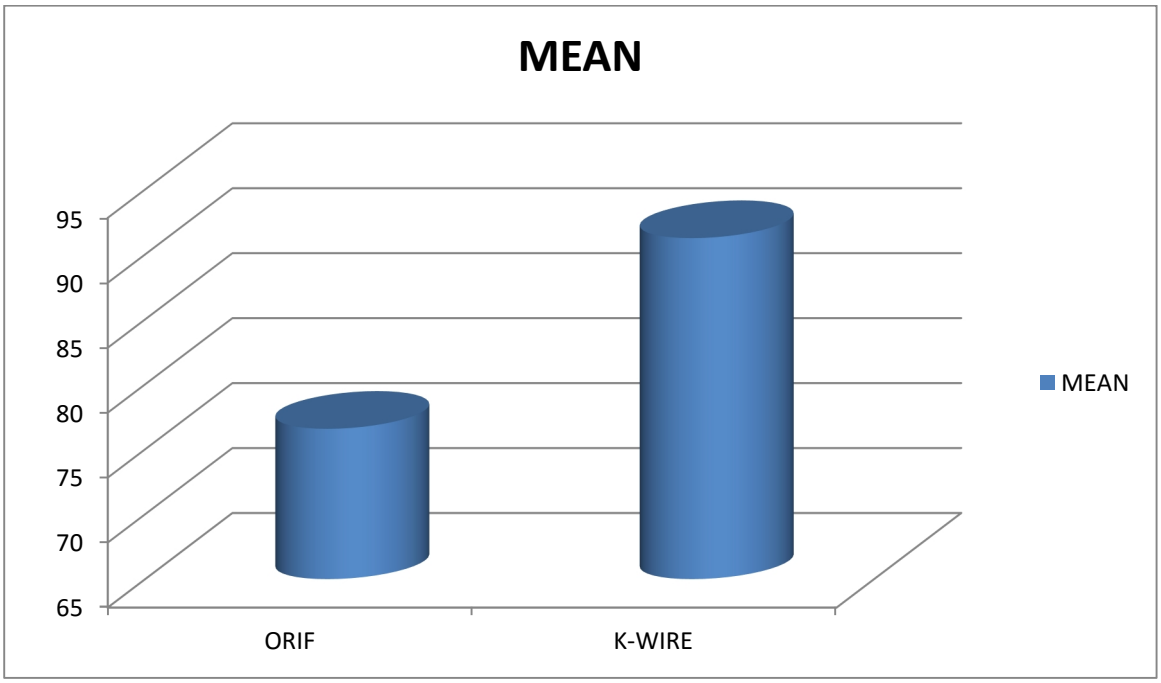
AOFAS SCORE FOLLOW UP	POOR			**FAIR**			GOOD			**EXCELLENT**		
	1 ½ M	3M	6M	**1 ½ M**	**3 M**	**6 M**	1 ½ M	3 M	6 M	**1 ½ M**	**3 M**	**6 M**
ORIF	3	1	1	**4**	**1**	**0**	0	4	2	**0**	**0**	**4**
Kirschner-wire	4	0	0	**4**	**2**	**0**	0	6	2	**0**	**0**	**6**
P VALUE	**0.38 (not significant)**											

AOFAS SCORE AT FINAL FOLLOW UP:



VII. AOFAS SCORE AT FINAL FOLLOWUP

PROCEDURE	MEAN	SD	P VALUE
Plate	76.57	3.93	0.38
Kirschner-wire	91.25	3.84	



VIII. COMPLICATIONS

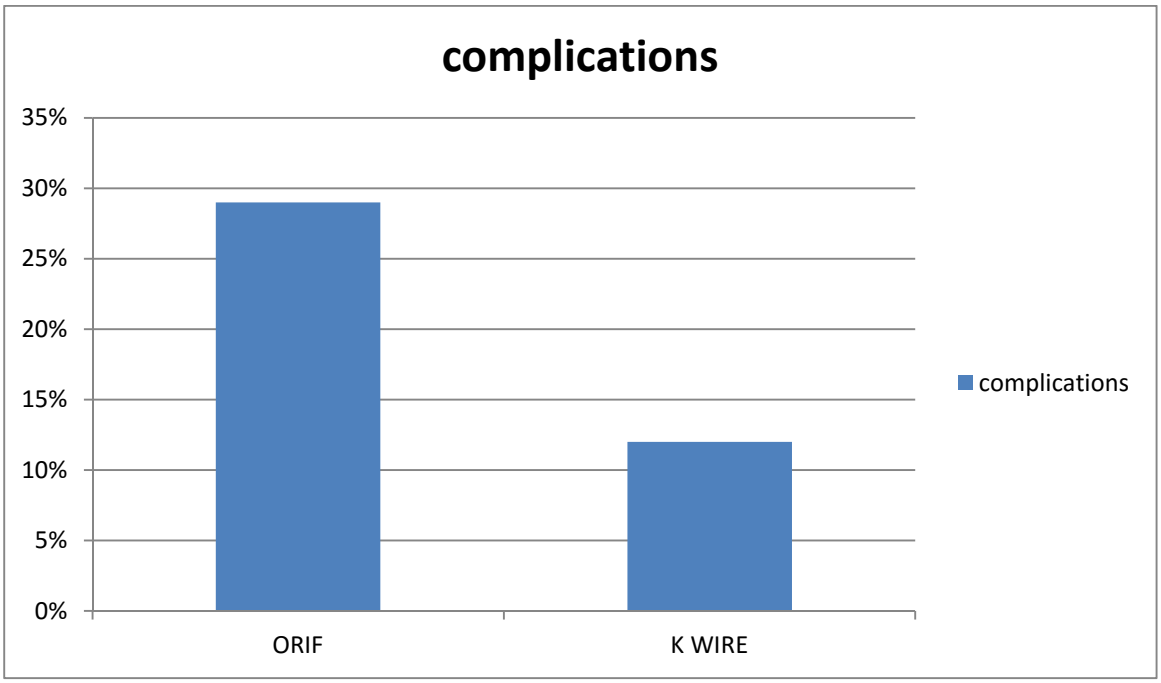
INFECTION – 3 TOTAL

PAIN - 0

RESTRICTION OF MOVEMENT – 0

LOSS OF REDUCTION - 0

COMPLICATIONS	NO. OF CASES	PERCENTAGE
ORIF	2	29%
KIRSCHNER WIRE FIXATION	1	12%
p value	0.48 (not significant)	



RESULTS

In this study, 7 patients underwent ORIF and 8 underwent K-wire fixation. The mean AOFAS score at final followupwaslower (76.57)in ORIF group compared to a higher score of (91.25)in Kwire group. Using unpaired T test, we tested for the level of significance by calculating p value. However p-value for the final followup score was 0.38(not significant).

Complications rate was high in ORIF group(29%) compared to the other group(12%). 2 patients in ORIF group got infected with one patient requiring implant exit. Only one patient has superficial infection in K-wire group which healed and had good outcome. Others like loss of reduction, metatarsalgia or restricted movements were not found in either of the groups. Overall the scoring was found better in K-wire group in our study.

DISCUSSION

Metatarsal fractures are the most common fractures involving the foot. Multiple metatarsal fractures most commonly occurred due to high energy trauma.This study was carried out after obtaining ethical committee clearance. In this study, we found that most of the fractures were due to RTA and few due to accidental fall. 80 % of cases occurs due to RTA and 20% of cases occurs due to accidental fall .

In our study males were most commonly affected. 93% of males were involved and 7% of females were involved.

In our study particular age groups were not involved, all age groups were involved. Less than 25 yrs age- 33% cases were involved. 26 to 35 yrs age- 20% cases were involved. 36 to 60 yrs – 33% cases were involved and more than 60 yrs of age 14% cases were involved.

In our study right side of the foot was involved more, 60% of cases having fracture in right foot and 40% of cases having fracture in left foot.

In our study 2 metatarsals were fixed with miniplate in single incision. So the skin stretching was increased while doing surgery..In our study duration of surgery was prolonged in ORIF with platinggroup compared with kirschner wire fixation. So this is the reason for getting minimal infection in plating group.

Kirschner wire was removed after 6 to 10 weeks of surgery. Plate was removed or planned to be removed after 1 year of surgery.

In our study, we used AOFAS score was used for assessment of the outcome of surgery. Scoring was done both before and after surgery. After surgery, assessment done at 1 and half months, 3 months and 6 months as followup to both groups. Though AOFAS score seemed better with k-wire group at initial followup, the final followup score was equally excellent in both groups.

In our study, comparing the two groups using UNPAIRED T-TEST for testing significance was found to be non-significant p-value=0.38 (>0.05). Similarly, in study by **MK O'Shea et al**, a one-way analysis of variance (ANOVA) was performed on the data to test for any significant difference in the fixation type used and the overall healing time. The ANOVA was found to be nonsignificant, $F(2,10) = 0.379$, $p > 0.05$.

Daniel Baumfeld et alconcludedthatPercutaneousantegrade surgical treatment is an effective alternative to other types of treatment for lateral metatarsal fractures, with a lower incidence of complications. In our study also, the overall complication rate was found to be lower in K-wire group (12%).

In our study the mean AOFAS score was found better in k-wire group. Similarly, **Hyong-Nyun Kim, MD et al** reported Closed antegrade intramedullary pinning was found to be a useful method for treating displaced metatarsal fractures and to allow immediate joint motion and partial weightbearing in a stiff-soled shoe.

CONCLUSION

In our study simple and compound grade I multiple metatarsal fractures treated at emergency within 24 hrs with open reduction and internal fixation with plate osteosynthesis and kirschner wire stabilization.

Open reduction and internal fixation with plate osteosynthesis done under tourniquet control. Kirschner wire stabilization done by closed technique under c arm control.

Both treatment modalities equally good, achieving good fracture union, decreased incidence of pain and achieve good range of movements with minimum complication.

Eventhough we had a minimal complications in plating group, we have achieved good union and excellent functional outcome at end of follow up.

AOFAS score was used to assess the functional outcome in our study. At the end of study AOFAS score was equal in both groups. So both techniques can be done for all metatarsal shaft fractures.

PROFORMA

- Name : IP No. :
- Age / sex : Occupation :
- DOA:
- DOS:
- DOD:
- Diagnosis :
- AOFAS SCALE:
- Nature of injury: Simple

  Comp grade I
- Associated injuries :
- Postoperative follow up :
- **RANDOMIZATION STUDY**

NO	NAME	A/S	Mode of injury	Diagnosis	Duration of surgery	AOFAS score before surgery	Procedure	follow up score in months			complications	Remarks
1	Ramakrishnan	18/m	RTA	# metatarsal 2^{nd} 3^{rd} simple	90 min	36	ORIF with plate osteosynthesis	72	86	92	Nil	Excellent
2	Ramesh	43/m	Accidental fall	# metatarsal 2^{nd} 3^{rd} simple	95 min	32	ORIF with plate osteosynthesis	74	82	90	Nil	Excellent
3	Karupaya	65/m	RTA	# metatarsal 2^{nd} 3^{rd} comp.	90 min	28	ORIF with plate osteosynthesis	62	-	-	Infections	Implant exit done
4	Manikandan	30/m	RTA	# metatarsal 2^{nd} 3^{rd} comp.	80 min	34	ORIF with plate osteosynthesis	72	84	92	Nil	Excellent
5	Eswari	35/f	RTA	# metatarsal 3^{rd} 4^{th} 5^{th} comp	100 min	32	ORIF with plate osteosynthesis	66	76	88	Nil	Good
6	Kalidoss	24/m	Accidental fall	# metatars	80 min	36	ORIF with plate	62	70	82	Infection	Good

				al 2nd 3rd simple			osteosynthesis					
7	Santhanapandy	18/m	RTA	# metatarsal 1st 2nd 3rd simple	75 min	42	ORIF with plate osteosynthesis	74	82	92	Nil	Excellent
8	Muthuraja	51/m	Accidental fall	# metatarsal 4th 5th simple	40 min	44	K wire fixation	72	82	94	Nil	Excellent
9	Arvindsamy	23/m	RTA	# metatarsal 2nd 3rd comp.	45 min	36	K wire fixation	64	88	94	Nil	Excellent
10	Chockalingam	40/m	RTA	# metatarsal 2nd 3rd comp.	30 min	38	K wire fixation	74	84	96	Nil	Excellent
11	Kannan	32/m	RTA	# metatarsal 1st 2nd 3rd 4th simple	50 min	32	K wire fixation	72	86	92	Nil	Excellent
12	Kannan	40/m	RTA	# metatarsal 2nd 3rd 4th 5th comp.	50 min	42	K wire fixation	66	72	88	Nil	Good
13	Gopal	25/m	RTA	# metatarsal 3rd	45 min	36	K wire fixation	68	80	92	Nil	Excellent

				$4^{th}5^{th}$ comp.								
14	Thattankaruppan	59/m	RTA	# metatarsal 2^{nd} 3^{rd} 4^{th} 5^{th} comp.	55 min	42	K wire fixation	70	82	90	Nil	Excellent
15	Minnagiri	63/m	RTA	# metatarsal 1^{st} 2^{nd} 3^{rd} comp.	45 min	38	K wire fixation	64	76	84	Infection	Good

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ETHICS COMMITTEE CERTIFICATE

Name of the Candidate	:	Dr.C.Chandru,
Course	:	PG in MS., Orthopaedics
Period of Study	:	2015-2018
College	:	MADURAI MEDICAL COLLEGE
Research Topic	:	Comparative analysis of functional outcome of multiple metatarsal fractures treated with plating and k wire fixation
Ethical Committee as on	:	17.03.2017

The Ethics Committee, Madurai Medical College has decided to inform that your Research proposal is accepted.

Member Secretary Chairman Dean / Convenor

Prof Dr.V.Nagaraajan
M.D., MNAMS, D.M., Dsc.,(Neuro), Dsc (Hon)
CHAIRMAN
IEC - Madurai Medical College
Madurai

DEAN
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URKUND

Urkund Analysis Result

Analysed Document: THESIS FINAL.docx (D31121817)
Submitted: 10/8/2017 9:45:00 PM
Submitted By: drcpchandrumbbs@gmail.com
Significance: 3 %

Sources included in the report:

Ortho Case.docx (D19447260)
THESIS PLAGIARISM.docx (D30857486)
thesis final.docx (D22337673)
http://www.mdguidelines.com/fracture-metatarsal-bones/definition
http://www.nlm.nih.gov/medlineplus/ency/patientinstructions/000553.htm

Instances where selected sources appear:

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